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(54) **EMI-attenuating air ventilation panel**

EMV-Belüftungseinsatz

Panneau de ventilation faisant écran aux ondes électromagnétiques

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(56) References cited:

**EP-A- 0 169 598                      EP-A- 0 610 730  
AT-B- 364 441                      FR-A- 2 741 504**

- **ARCHAMBEAULT, BRENCH: "modeled and  
measured results from two proposed standard  
EMI modeling problems." IEEE 1995  
INTERNATIONAL SYMPOSIUM ON  
ELECTROMAGNETIC COMPATIBILITY, 14 - 18  
August 1995, pages 349-352, XP002104417**

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## Description

### Field of the invention

[0001] The present invention generally relates to electrical and electronic apparatus. More particularly, the invention relates to apparatus for cooling an electrical or electronic system, and for shielding electromagnetic interference (EMI) radiation generated by the system during operation thereof.

### Background of the invention

[0002] In today's competitive electronics marketplace, there is a demand for higher frequency computer components while consumers demand smaller packaging. These requirements have lead to much higher temperatures within the electronic package, requiring more cooling. Higher frequency computer components are also generating more electromagnetic interference or EMI in addition to the heat which, if not properly shielded, can interfere with other electronic equipment by way of radiation or conduction. Consequently, electronic manufacturers often face a design trade-off between cooling the package and shielding for EMI, since EMI radiation typically escapes through air holes commonly used for cooling purposes. It should incidently be noted that radiations generated by electronic packages can include electromagnetic energy of wavelengths along various points of the spectrum such as radio frequency interference. As used herein, the term electromagnetic interference (EMI) refers to interfering electromagnetic energy of any wavelength.

[0003] Printed circuit boards used in various types of electronic equipment are typically mounted within a housing structure. During operation of the circuit board, EMI radiation is generated within the board, emanates therefrom, and must be substantially prevented from escaping outwardly through the housing structure. One solution to the above problem is to provide the housing with the necessary EMI radiation shield by coating the interior of the housing with a metallic material which is brought into contact with a grounding portion of the electronic circuits, such as the ground plane of the circuit board disposed within the housing. Other types of EMI shields positioned around the circuit board may be alternatively used. For instance it has been realized in the art that a foil shield, placed around the electronic circuitry and connected to ground would reduce EMI radiations. Typically aluminum or copper is used for such shields. However, such aluminum and copper foil shields, while somewhat effective, have proven to be costly to manufacturers. Moreover, none of the above solutions facilitate air circulation or improve cooling capabilities of the system.

[0004] In order to allow air circulation while reducing EMI, arrays of small flat holes have been used to shield against EMI, but the holes had to be so small that dust

and lint would easily collect and clog the holes. In another solution, stacked plates of holes arranged into an array have been used, but the weight and cost of this solution make it unattractive. Yet another solution known in the art uses screen meshes, but this solution creates a high impedance air flow and presents a great risk of lint and dust build-up. Honeycomb vents have also been used for the same purpose, but the cost is prohibitive.

[0005] Accordingly, it is an object of the present invention to attenuate EMI radiation entering or leaving electronic packages to an acceptable level. It is a further object of the invention to produce an EMI radiation shielding device which allows for low impedance airflow through the package for cooling purposes. It is a further object of the invention to lower the cost compared to traditional EMI solutions. It is a still further object to reduce problems related to lint and dust collection around cooling holes.

### Summary of the invention

[0006] In an embodiment, the invention includes an EMI-attenuating air ventilation panel for an electronic device enclosure. This air ventilation panel is typically made of an electrically conductive panel, and has at least one air ventilation hole formed in it. Around the periphery of the air ventilation hole an electrically conductive tube is electrically and mechanically connected to the panel. The axis of the tube extends away from said panel in a direction approximately normal to the panel. The ventilation panel has two sides, respectively referred to as upstream and downstream airflow sides. A smooth surface joins the upstream airflow side of the electrically conductive panel with the inner surface of the electrically conductive tube.

[0007] In another embodiment, the invention includes an EMI-attenuating air ventilation panel for an electronic device enclosure with a plurality of air ventilation holes formed in it. Each of these air ventilation holes has an electrically conductive tube which is both electrically and mechanically coupled to the panel at the periphery of the air ventilation hole. The axis of the tube extends away from the panel in a direction approximately normal to the panel. Both the air ventilation hole and the tube have typically a circular cross section. The side of the ventilation panel where the tubes are connected is referred to as the downstream airflow side. The other side is the upstream airflow side. An air ventilation hole has a smooth edge around its periphery on the upstream airflow side of the electrically conductive panel. This facilitates air circulation through the tube. A typical material used for the panel is a zinc-plated steel sheet having a thickness of approximately 1mm. The electrically conductive tubes can then be extruded from the sheet of zinc-plated steel. The length-to-diameter ratio of each of the electrically conductive tubes is between approximately 0.5 and 1.0. Each of the tubes has a length of

approximately 3.5mm, and a diameter of approximately 4.8mm. The relative spacing of the air ventilation holes is approximately 8.5mm center-to-center.

**[0008]** In a further embodiment, the invention includes an electronic device enclosure having improved air ventilation and EMI attenuation characteristics. This enclosure includes a casing; an EMI-attenuating air ventilation panel made with an electrically conductive panel having a plurality of air ventilation holes formed in it; and a cooling fan for circulating air into the casing through the air ventilation holes. Each of the ventilation holes has an electrically conductive tube which is electrically and mechanically coupled to the panel at the periphery of the air ventilation hole with the axis of the tube extending away from the panel in an approximately perpendicular direction relative to the panel. The air ventilation holes and the tubes have typically a circular cross section. The side of the panel with the tubes is referred to as the downstream airflow side, with the other side being the upstream airflow side. The periphery of a hole has a smooth edge on the upstream airflow side in order to facilitate airflow from the upstream airflow side, through the tube, and out to the downstream airflow side. A typical material used for the panel is a zinc-plated steel sheet having a thickness of approximately 1mm. The electrically conductive tubes can then be extruded from the sheet of zinc-plated steel. The length-to-diameter ratio of each of the electrically conductive tubes is between approximately 0.5 and 1.0. Each of the tubes has a length of approximately 3.5mm, and a diameter of approximately 4.8mm. The relative spacing of the air ventilation holes is approximately 8.5mm center-to-center.

#### **Brief description of the drawings**

**[0009]** FIG. 1 is an oblique view of the upstream airflow side of an EMI-attenuating air ventilation panel with 17 air ventilation holes according to the present invention.

**[0010]** FIG. 2 is a side view of the ventilation panel of FIG. 1.

**[0011]** FIG. 3 is a frontal view of the upstream airflow side of the ventilation panel of FIG. 1 showing the smooth surface around the periphery of the air ventilation holes for an improved airflow through the tube.

**[0012]** FIG. 4 is an oblique view of the downstream airflow side of the ventilation panel of FIG. 1.

**[0013]** FIG. 5 is an oblique view of the upstream airflow side of an EMI-attenuating air ventilation panel.

**[0014]** FIG. 6 is an oblique view of the downstream airflow side of the EMI-attenuating air ventilation panel of FIG. 5.

**[0015]** FIG. 7 is a frontal view of the upstream airflow side of the EMI-attenuating air ventilation panel of FIG. 5.

**[0016]** FIG. 8 is an oblique cut-away view of an electronic device enclosure having a cooling fan and an EMI-

attenuating air ventilation panel.

**[0017]** FIG. 9 is a simplified side view of a test setup for EMI attenuation measurement of the air ventilation panel according to the present invention.

#### **Detailed description of the preferred embodiments**

**[0018]** As shown in the drawings for purposes of illustration, the invention is embodied in a novel air ventilation panel for cooling and EMI containment. A system according to the invention provides substantial EMI attenuation entering or leaving packages on a circuit board; while reducing airflow impedance through the package and therefore improving the cooling capabilities of the system. Existing solutions such as honeycomb vents, screen meshes, stacked perforated plates and various others have typically several disadvantages such as allowing a difficult airflow, being prone to dust and lint collection and clogging, heavy weight, and high manufacturing costs.

**[0019]** An EMI-attenuating air ventilation panel according to the present invention provides a multitude of extruded air ventilation holes for EMI containment and cooling. The resulting panel is simple and cost-effective. It provides an efficient EMI containment solution at a lower cost and adds only a low impedance to the airflow through the system. Additional advantages include reducing product weight, and minimizing the risk of inadequate cooling due to lint and dust collection.

**[0020]** Depicted in FIG. 1 is an oblique view of an EMI-attenuating air ventilation panel 1 for an electronic device enclosure. The ventilation panel includes an electrically conductive panel 10 having an air ventilation hole 12 formed in it. FIG. 2 is a side view of the ventilation panel and depicts an electrically conductive tube 14 which is electrically and mechanically coupled to the electrically conductive panel at the periphery 15 of an air ventilation hole. The axis of this electrically conductive tube extends away from the electrically conductive panel in a direction approximately normal to the electrically conductive panel. FIG. 3 shows a side of the ventilation panel referred to as the upstream airflow side 16. Similarly, the opposite side of the ventilation panel which is viewed in FIG. 4 is referred to as the downstream airflow side 18. As depicted in the figures, a smooth surface 20 joins the upstream airflow side of the electrically conductive panel with the inner surface 21 of the electrically conductive tube. The air ventilation hole and the electrically conductive tube both have typically a circular cross section. The most common material used for the EMI-attenuating air ventilation panel is usually metal. Accordingly, the electrically conductive tube is made with extruded metal.

**[0021]** Another embodiment is depicted in FIGS. 5-7, showing an EMI-attenuating air ventilation panel 3 for an electronic device enclosure with a plurality of air ventilation holes formed in it. Each of these air ventilation holes has an electrically conductive tube which is both

electrically and mechanically coupled to the panel at the periphery of the air ventilation hole. The axis of the tube extends away from the panel in a direction approximately normal to the panel. Both the air ventilation hole and the tube have typically a circular cross section. FIG. 6 illustrates the side of the ventilation panel where the tubes are connected to the panel around each air ventilation hole, which is referred to as the downstream airflow side. The other side of the ventilation panel is the upstream airflow side, depicted in FIG. 5 and FIG. 7. An air ventilation hole has a smooth edge around its periphery on the upstream airflow side of the electrically conductive panel. This facilitates air circulation through the tube. A typical material used for the panel is a zinc-plated steel sheet having a thickness of approximately 1mm. The electrically conductive tubes can then be extruded from the sheet of zinc-plated steel. The length-to-diameter ratio of each of the electrically conductive tubes is usually between approximately 0.5 and 1.0. Each of the tubes has typically a length of approximately 3.5mm, and a diameter of approximately 4.8mm. The relative spacing of the air ventilation holes is approximately 8.5mm center-to-center.

**[0022]** In yet another embodiment, the invention includes an electronic device enclosure 2 having improved air ventilation and EMI attenuation characteristics as depicted in FIG. 8. This enclosure includes a casing 22; an EMI-attenuating air ventilation panel 3 made with an electrically conductive panel having a plurality of air ventilation holes formed in it; and a cooling fan 24 for circulating air into the casing through the air ventilation holes. Each of the ventilation holes has an electrically conductive tube which is electrically and mechanically coupled to the panel at the periphery of the air ventilation hole with the axis of the tube extending away from the panel in an approximately perpendicular direction relative to the panel. The air ventilation holes and the tubes have typically a circular cross section. The side of the panel with the tubes is referred to as the downstream airflow side, with the other side being the upstream airflow side. The periphery of a hole has a smooth edge on the upstream airflow side in order to facilitate airflow from the upstream airflow side, through the tube, and out to the downstream airflow side of the panel. The smooth edge improves the circulation of air through the tube, compared to an opening with sharp edges. A typical material used for the panel is a zinc-plated steel sheet having a thickness of approximately 1mm. The electrically conductive tubes can then be formed in the sheet of zinc-plated steel using an extruding operation. Through an iterative process, the optimum hole spacing can be determined for any given material and set of constraints. For example, in the case of 1mm thick zinc-plated steel, the optimal length-to-diameter ratio of each of the electrically conductive tubes is determined to be between approximately 0.5 and 1.0 in order to allow the greatest number of holes for a given area. Accordingly, each of the tubes has a length of ap-

proximately 3.5mm, and a diameter of approximately 4.8mm. These tubes act as a collection of waveguide below cutoff attenuators. The cross sectional dimensions of the tubes do not support propagation of electromagnetic energy below a wavelength related to those dimensions. Consequently, the EMI is effectively attenuated by the length of the tube leaving the air ventilation hole, and the panel is nearly opaque to signals below that cutoff frequency. The relative spacing of the air ventilation holes is approximately 8.5mm center-to-center.

**[0023]** As discussed above, the EMI-attenuating air ventilation panel described in this disclosure provides a superior barrier for radiated electromagnetic emissions when compared to a conventional "flat" hole array structure. This design provides extruded hole walls creating a conductive tube at each hole location. The tube acts as a waveguide below cutoff, resulting in significant signal attenuation at high frequencies. This technique mimics the performance of honeycomb filter assemblies at a much lower cost basis. Extensive testing has confirmed the superiority of the present invention. One such test was performed with two sample panels having a six-inch by six-inch array of holes. One sample containing conventional holes was used as the control element in this test. The other sample contained the extruded hole design described in this disclosure, and is represented as the panel 30 in FIG. 9. The tests were conducted using a custom-built shielding effectiveness tester (SET) 32. This test fixture features near-field source excitation with mode stirring at both the source 34 and the antennae 36. The frequency range of the test represents the maximum flat response region of the SET fixture (290 MHz to 2 GHz). All readings are relative to a normalized baseline where no test sample is in place. Testing in the SET fixture demonstrates a shielding effectiveness of 25 dB for the flat hole structure and a superior 40 dB for the extruded structure. A 15 dB increase in shielding effectiveness translates to more than a five to one signal reduction. This method of testing is representative of actual computer product implementations of EMI shielding solutions. Good correlation has been demonstrated between SET testing and testing performed in FCC qualified chambers. The FCC is a U.S. regulatory body requiring that manufacturers of certain classes of electronic equipment test and certify that radio frequency emissions from that equipment are within prescribed limits. Based on these tests, the disclosed EMI-attenuating air ventilation panel featuring extruded tubes offers superior shielding performance over more conventional "flat" structures.

**[0024]** From the foregoing it will be appreciated that the EMI-attenuating air ventilation panel provided by the invention represents a significant advance in the art. The present invention provides a single cost-effective, easy, and efficient way to satisfy two demanding requirements of most electrical and electronic systems: Cooling and EMI attenuation. An air ventilation panel embodying the invention attenuates EMI radiation entering or leav-

ing the package to an acceptable level, while allowing for low impedance airflow through the system since no significant resistance is imposed to the airflow within the system. In addition to its elegant simplicity, the invention lowers the cost and the weight of the final product compared to traditional EMI solutions. Moreover, since the extruded holes can be larger and still contain EMI radiation, the problem of lint and dust collection around the holes is also eliminated. A panel embodying the present invention has the additional advantages of being lightweight, easy to manufacture, easy to assemble and disassemble in a system, and easy to clean.

## Claims

1. An EMI-attenuating air ventilation panel (1) for an electronic device enclosure (2) comprising:

an electrically conductive panel (10) having at least one air ventilation hole (12) formed in it, wherein said electrically conductive panel (10) has an upstream airflow side (16) and a downstream airflow side (18);

an electrically conductive tube (14) electrically and mechanically coupled to said electrically conductive panel (10) at the periphery (15) of at least one of said air ventilation holes (12), the axis of said electrically conductive tube (14) extending away from said electrically conductive panel (10) in a direction approximately normal to said electrically conductive panel (10); and

a smooth surface (20) joining said upstream airflow side (16) of said electrically conductive panel (10) with the inner surface (21) of said electrically conductive tube (14).

2. The EMI-attenuating air ventilation panel (1) of claim 1, wherein each of said air ventilation holes (12) has an unrestricted circular cross section and each of said electrically conductive tubes (14) defines an air passageway having an unrestricted circular cross section.
3. The EMI-attenuating air ventilation panel (1) of claim 1, wherein the length-to-cross section ratio of each of said electrically conductive tubes (14) is between approximately 0.5 and 1.0.
4. The EMI-attenuating air ventilation panel (1) according to claim 1, wherein each of said electrically conductive tubes (14) are waveguides having substantially constant cross sectional areas.
5. The EMI-attenuating air ventilation panel (1) according to claim 1, wherein the length of each of said electrically conductive tubes (14) is approximately

3.5 mm, and the diameter of each of said electrically conductive tubes (14) is approximately 4.8 mm.

6. An electronic device enclosure (2) comprising:

a casing (22); and  
at least one EMI-attenuating air ventilation panel (3) according to any preceding claim.

## Patentansprüche

1. Ein EMI-Dämpfungs-Belüftungspaneel (1) für eine Umhüllung (2) einer elektronischen Vorrichtung, die folgende Merkmale aufweist:

ein elektrisch leitfähiges Paneel (10) mit zumindest einem Belüftungslöcher (12), das in demselben gebildet ist, wobei das elektrisch leitfähige Paneel (10) eine stromaufwärts angeordnete Luftstromseite (16) und eine stromabwärts angeordnete Luftstromseite (18) aufweist;

eine elektrisch leitfähige Röhre (14), die mit dem elektrisch leitfähigen Paneel (10) an dem Umfang (15) von zumindest einem der Belüftungslöcher (12) elektrisch und mechanisch gekoppelt ist, wobei sich die Achse der elektrisch leitfähigen Röhre (14) von dem elektrisch leitfähigen Paneel (10) weg, in eine Richtung näherungsweise senkrecht zu dem elektrisch leitfähigen Paneel (10) erstreckt; und

eine glatte Oberfläche (20), die die stromaufwärts angeordnete Luftstromseite (16) des elektrisch leitfähigen Paneels (10) mit der inneren Oberfläche (21) der elektrisch leitfähigen Röhre (14) verbindet.

2. Das EMI-Dämpfungs-Belüftungspaneel (1) gemäß Anspruch 1, bei dem jedes der Belüftungslöcher (12) einen uneingeschränkten kreisförmigen Querschnitt aufweist und jede der elektrisch leitfähigen Röhren (14) einen Luftdurchgang mit einem uneingeschränkten kreisförmigen Querschnitt definiert.
3. Das EMI-Dämpfungs-Belüftungspaneel (1) gemäß Anspruch 1, bei dem das Längen-Querschnittsverhältnis von jeder der elektrisch leitfähigen Röhren (14) zwischen näherungsweise 0,5 und 1,0 ist.
4. Das EMI-Dämpfungs-Belüftungspaneel (1) gemäß Anspruch 1, bei dem jede der elektrisch leitfähigen Röhren (14) ein Wellenleiter mit einem im wesentlichen konstanten Querschnittsbereich ist.
5. Das EMI-Dämpfungs-Belüftungspaneel (1) gemäß Anspruch 1, bei dem die Länge von jeder der elek-

trisch leitfähigen Röhren (14) näherungsweise 3,5 mm ist und der Durchmesser von jeder der elektrisch leitfähigen Röhren (14) näherungsweise 4,8 mm ist.

6. Eine Umhüllung (2) einer elektronischen Vorrichtung, die folgende Merkmale aufweist:

ein Gehäuse (22); und

zumindest ein EMI-Dämpfungs-Belüftungspaneel (3) gemäß einem der vorhergehenden Ansprüche.

## Revendications

1. Panneau de ventilation d'air atténuant les perturbations électromagnétiques (1) pour une enceinte (2) de dispositif électronique, comportant :

un panneau électriquement conducteur (10) ayant au moins un orifice de ventilation d'air (12) formé dans celui-ci, ledit panneau électriquement conducteur (10) ayant un côté d'écoulement d'air amont (16) et un côté d'écoulement d'air aval (18),

un tube électriquement conducteur (14) relié électriquement et mécaniquement audit panneau électriquement conducteur (10) à la périphérie (15) d'au moins un desdits trous de ventilation d'air (12), l'axe dudit tube électriquement conducteur (14) s'éloignant dudit panneau électriquement conducteur (10) dans une direction approximativement perpendiculaire audit panneau électriquement conducteur (10), et

une surface lisse (20) reliant ledit côté d'écoulement d'air amont (16) dudit panneau électriquement conducteur (10) à la surface intérieure (21) dudit tube électriquement conducteur (14).

2. Panneau de ventilation d'air (1) atténuant les perturbations électromagnétiques selon la revendication 1, dans lequel chacun desdits trous de ventilation d'air (12) a une section transversale circulaire non-restreinte et chacun desdits tubes électriquement conducteurs (14) définit un passage d'air ayant une section transversale non-restreinte.

3. Panneau de ventilation d'air (1) atténuant les perturbations électromagnétiques selon la revendication 1, dans lequel le rapport longueur sur coupe transversale de chacun desdits tubes électriquement conducteurs (14) est compris entre approximativement 0,5 et 1,0.

4. Panneau de ventilation d'air (1) atténuant les per-

turbations électromagnétiques selon la revendication 1, dans lequel chacun desdits tubes électriquement conducteurs (14) est un guide d'onde ayant une surface en coupe transversale sensiblement constante.

5. Panneau de ventilation d'air (1) atténuant les perturbations électromagnétiques selon la revendication 1, dans lequel la longueur de chacun desdits tubes électriquement conducteurs (14) est approximativement de 3,5 mm, et le diamètre de chacun desdits tubes électriquement conducteurs (14) est approximativement de 4,8 mm.

6. Enceinte de dispositif électronique (2), comportant :

un boîtier (22), et

au moins un panneau de ventilation d'air (3) atténuant les perturbations électromagnétiques selon l'une quelconque des revendications précédentes.

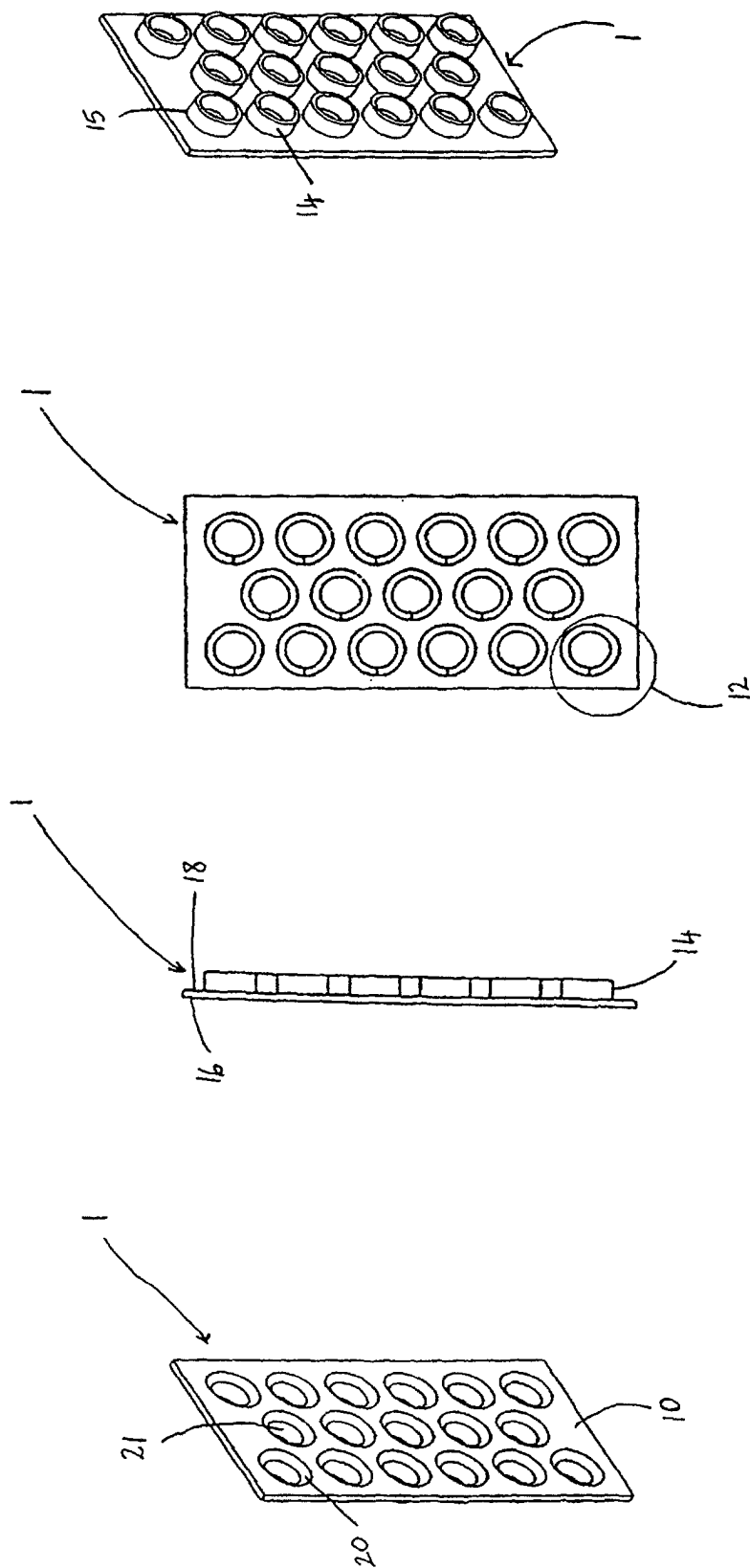


FIG. 1

FIG. 2

FIG. 3

FIG. 4

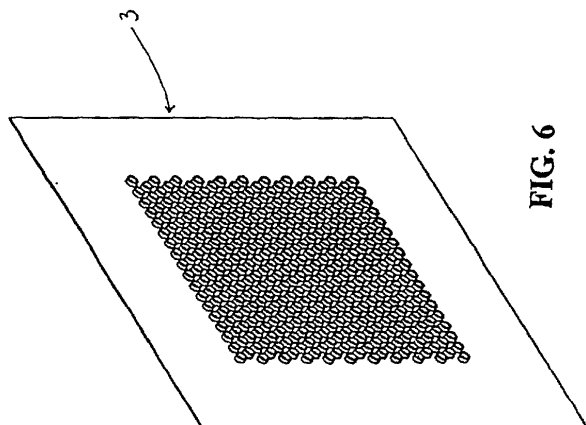


FIG. 6

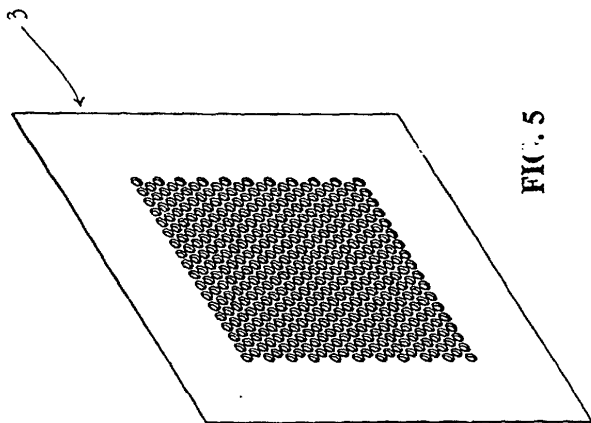


FIG. 5

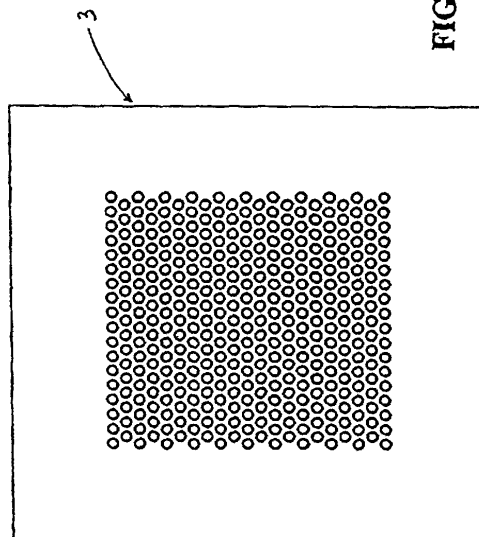
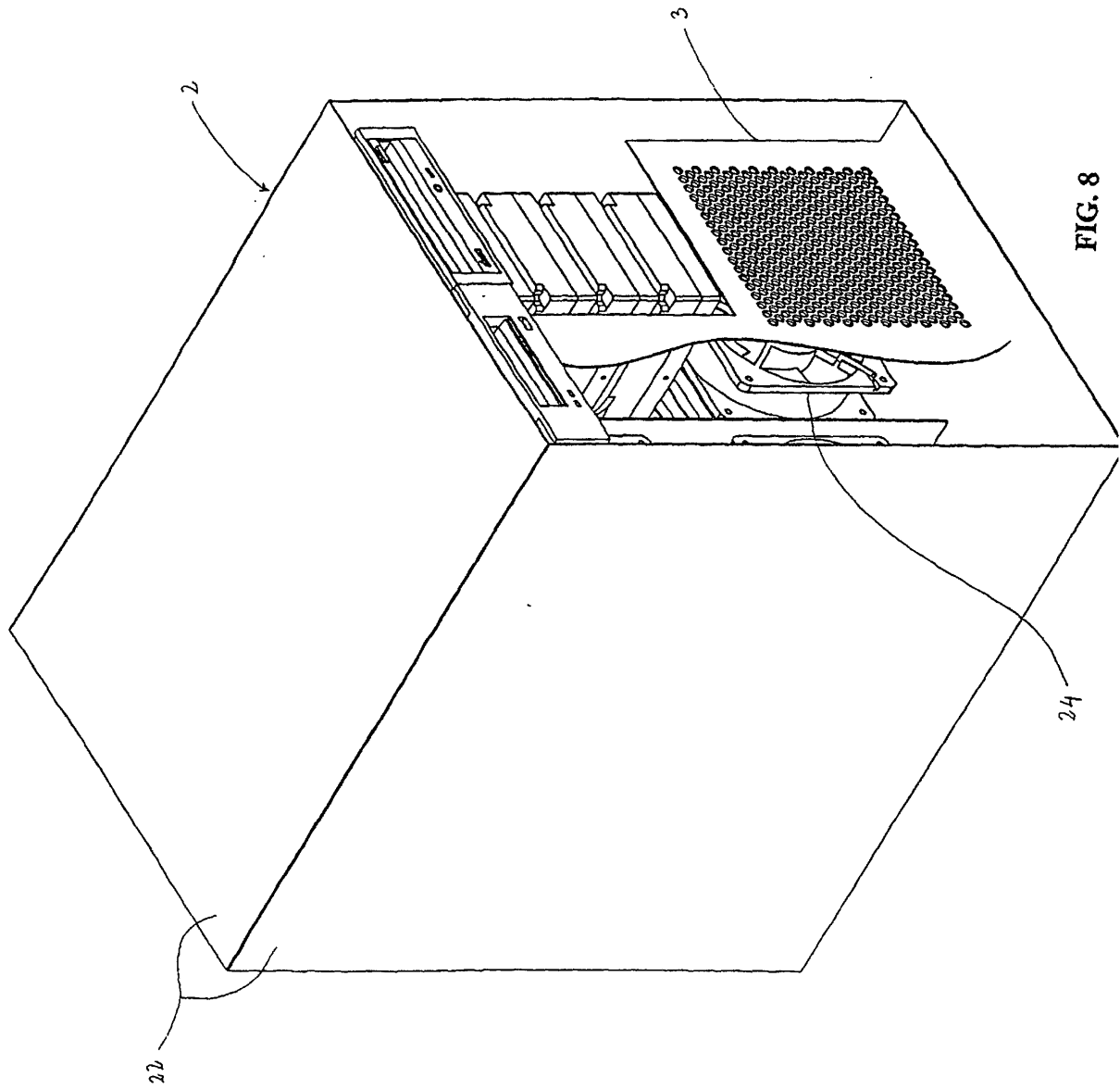


FIG. 7





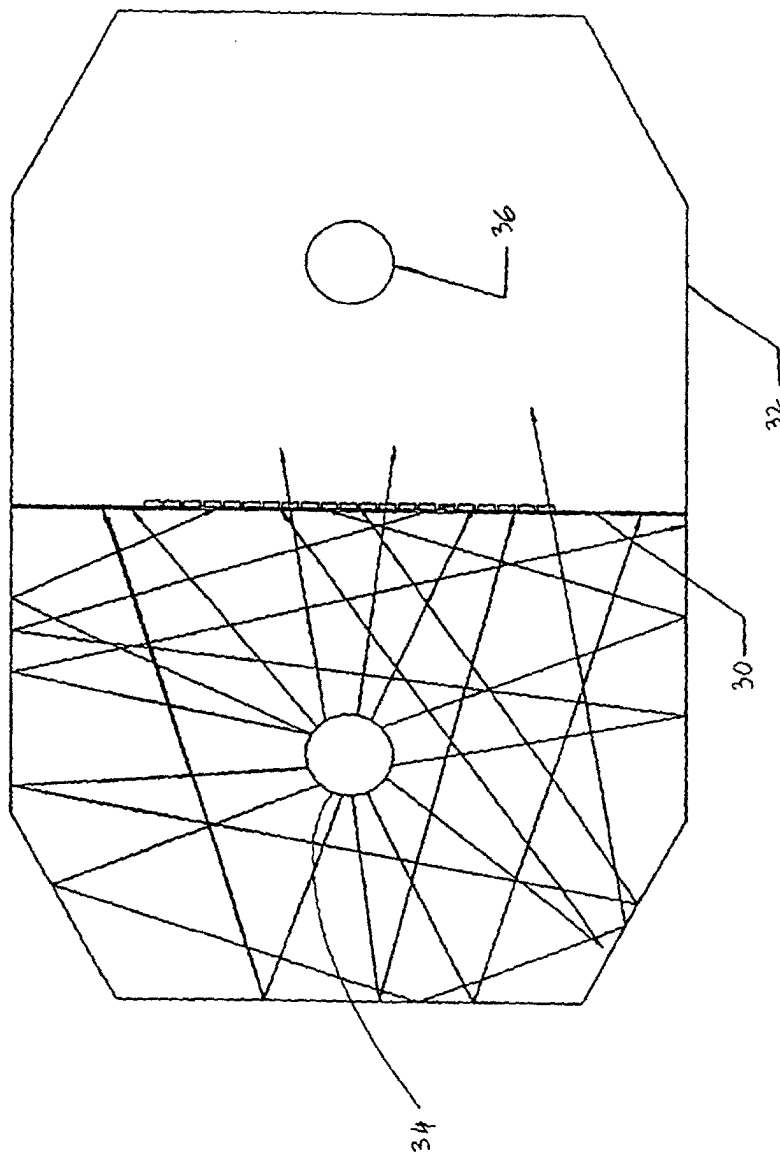


FIG. 9